SUMMARY OF CALFED BAY-DELTA PROGRAM ANALYSIS STRATEGY FOR WATER MANAGEMENT FACILITIES AND OPERATIONS

Several assessment variables have been identified that will be used to evaluate and compare water management effects of CALFED Bay Delta Program (CALFED) alternative components. The existing and proposed surface-water management facilities (e.g., reservoirs, diversions, and canals) together with the current and proposed groundwater capabilities (i.e., available storage volume, pumping capacity, and recharge capacity) for the Sacramento River and San Joaquin River basins must be included to accurately portray likely future Delta channel flows and exports, as well as describe conditions in tributary streams used as habitat for anadromous fish species. The capacities and operating rules for these water management facilities must be as flexible and general as possible so that a full range of potential alternative components and operating priorities can be simulated and evaluated as part of the CALFED programmatic assessment strategy.

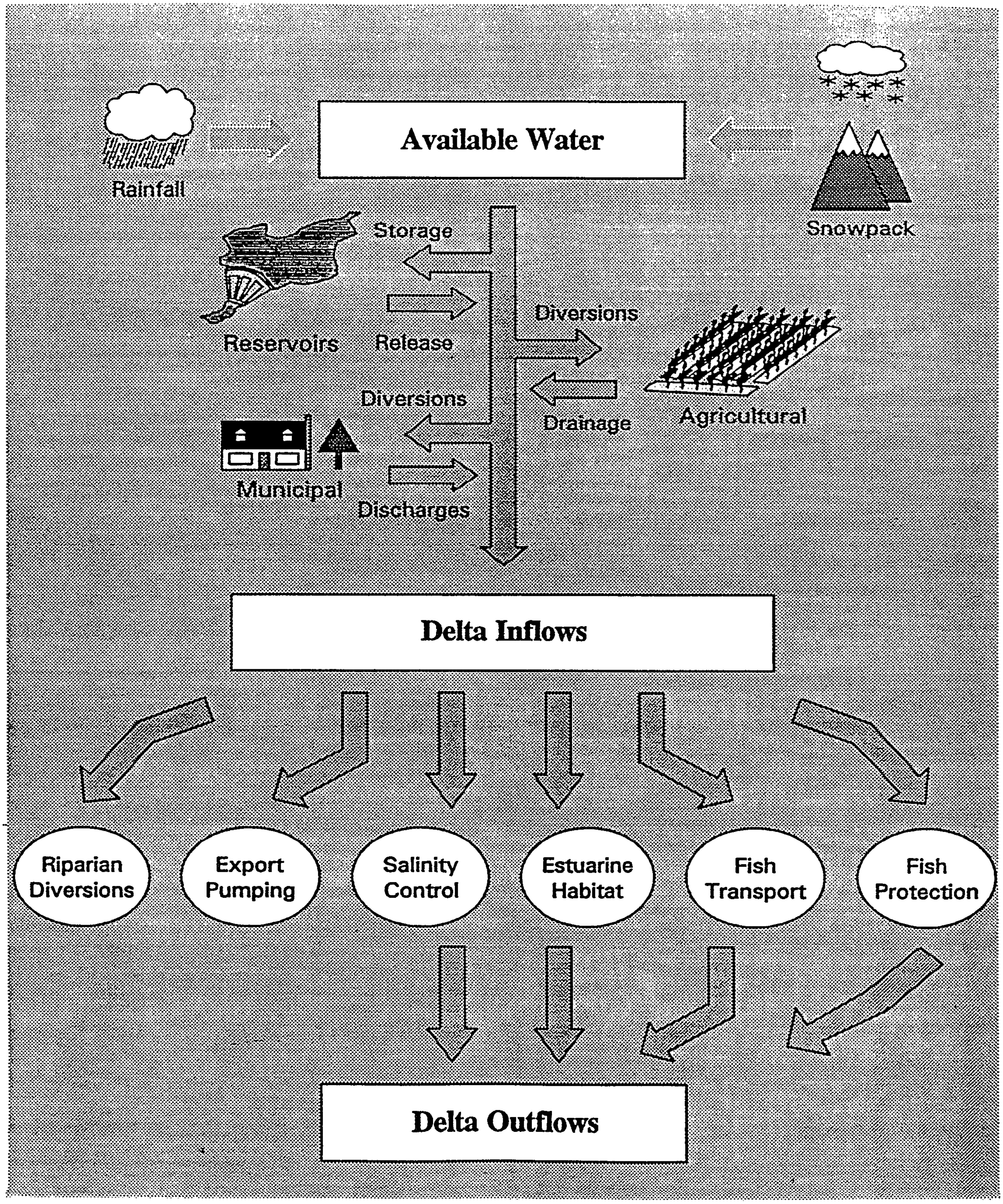
The major characteristic of Central Valley hydrology is the extreme variation in both seasonal and annual runoff that is available for allocation to various beneficial uses. The effects of hydrologic variability are usually included in water management planning by simulating the operation of proposed facilities using the monthly natural (i.e., unimpaired) runoff conditions estimated from measured flows from 1922 to the present (i.e., 1996). The basic water management approach has been to store excess runoff in surface reservoirs and later release the stored water for downstream beneficial uses (e.g., diversions). The recognition of increased requirements for instream flows to protect and promote habitat conditions for fish and wildlife populations (i.e., instream beneficial uses) has created a water allocation dilemma, as illustrated in Figure 1. Allocation of available water for beneficial uses must now include substantial instream flows, as well as traditional diversion and export demands.

Figure 2 illustrates the general water management framework consisting of monthly inflows, available reservoir storage capacity, demands for diversions, targets for instream flows, and reservoir spills (i.e., water released from reservoirs that is in excess of downstream requirements for diversions or instream flows). This illustration of the water management framework should be expanded to include the interaction between several tributary reservoirs and common downstream Delta outflow requirements and export demands. This has been generally accomplished using the water planning models such as PROSIM/SANJASM and DWRSIM; however, the existing planning models do not provide a sufficiently comprehensive and flexible allocation and accounting of these competing demands on California's limited water supply. The CALFED programmatic assessment strategy will require some modifications and enhancements of the existing planning models to obtain the necessary flexibility and accounting to support the assessment of all potential future allocation and operation strategies for Delta water resources.

Figure 3 illustrates the suggested CALFED assessment strategy for comprehensive and flexible allocation and accounting of demands for diversions and exports, as well as instream flow and Delta outflow targets. This strategy places emerging objectives for instream flows and Delta outflow on an equal basis with traditional demands for diversions and exports from the Delta. The available runoff and storage capacity is allocated using an adaptive management approach (e.g., recognizing that water supply forecasts and information about the response of fish populations will change during the season) that attempts to balance the competing requirements for diversions and instream flows. The CALFED assessment strategy must include the full range of potential water management facilities, but it must also incorporate the wide range of operating rules and water supply allocation approaches that will be possible under adaptive water management.

This proposed water management assessment strategy will be illustrated with some example relationships using simulations of the 1995 Water Quality Control Plan made with DWRSIM for the State Water Resources Control Board.

Figure 1
The Delta Water Allocation Dilemma



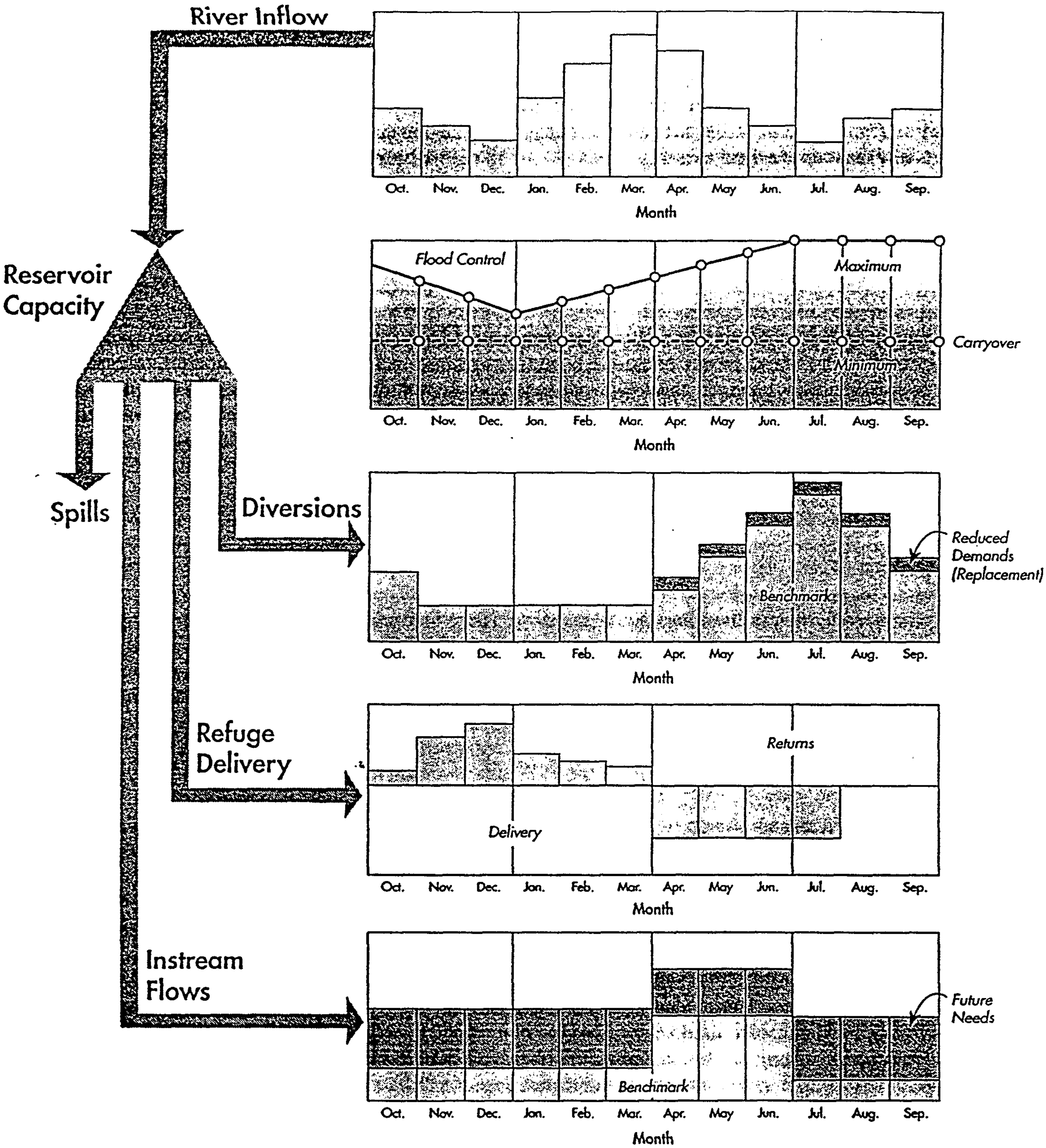


Figure 2
Schematic of Monthly Patterns of Inflows, Reservoir Capacity, Diversions, Refuge Needs, Instream Flows, and Spills

Figure 3
CALFED Water Management Assessment Strategy

Runoff or Inflow

Available Storage Capacity

- Flood control (constraints)
- Carryover target (rules)

Instream Flows/Outflow

- Requirements (constraints)
- Targets (rules)
- Deficit/surplus from target

Diversions/Exports

- Capacities (constraints)
- Targets (rules)
- Limits (rules)
- Deficit/surplus from target

Spills

- Above diversion capacity
- Above local storage capacity
- Above diversion limits

CALFED Analytical Variables and Relationships

Assessment Variable	Supporting Variable		CALFED Action Component*

I. Physical Environment

B. Water Supply Facilities and Operations

Assessment Variable	Supporting Variable		CALFED Action Component*
1. Reservoir storage (10-20 locations)	Capacity		New or expanded storage
	Runoff		INPUTS
	Flood control	Flood storage	FIXED
		Channel capacity	FIXED
	Demands		Demand management, conjunctive use, transfers
	Instream targets		IFIM requirements, pulse flows
2. Instream flows (10-20 locations)	Instream targets		IFIM requirements, pulse flows
	Runoff		INPUTS
	Storage		FLOWS
	Demands		Demand management, conjunctive use, transfers
3. Diversions/exports (10-20 locations)	Runoff		INPUT
	Demands	Water contracts	FIXED
		Water rights	FIXED
		Water costs	FEEDBACK
	Diversion limits		Operation rules
	Reservoir storage		FLOWS
	Groundwater pumping		FEEDBACK
4. Agricultural drainage (10-20 locations)	Rainfall		INPUT
	Irrigation	Crop acres	Land retirement, agricultural conservation
		Applied electrical conductivity	FEEDBACK
	Soils		FIXED
	Drainage facilities		Drainage management facilities

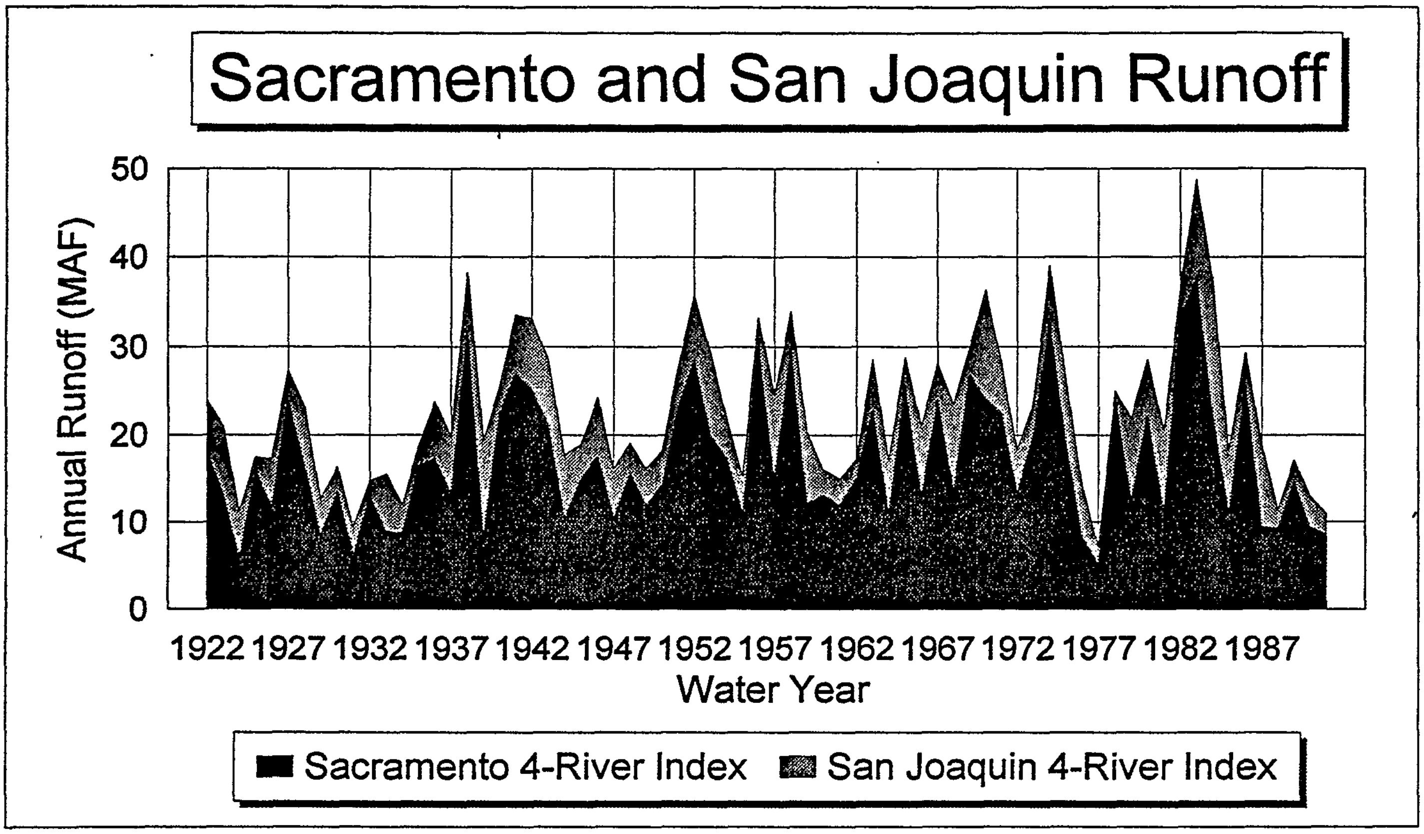
CALFED Analytical Variables and Relationships

Assessment Variable	Supporting Variable	CALFED Action Component*

* FIXED = relationship is assumed to not change.
INPUT = monthly hydrologic or meteorologic conditions.
FEEDBACK = relationship is addressed elsewhere in table.
FLOWS = water management control.
IFIM = Instream Flow Incremental Methodology
BMP = Best Management Practices

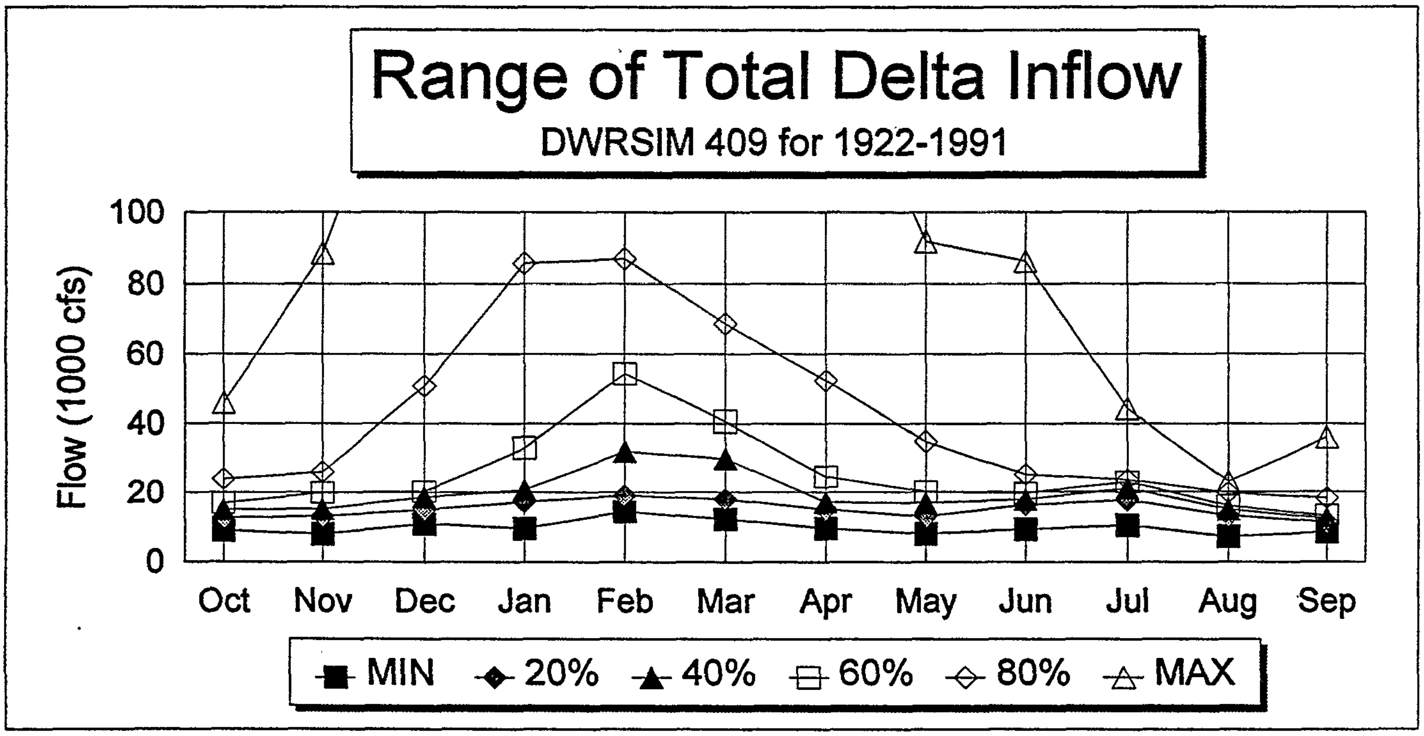
RELATIONSHIP 1

"Available Annual Runoff for 1922-1991" (water year) indicates that the available runoff for the Sacramento River (i.e., 4-River Index) and San Joaquin River (i.e., 4-River Index) varies from as low as 7 million acre-feet (MAF) to as high as 48 MAF. Although drought sequences are present in the historical record (i.e., 1929-1934 and 1987-1992), there is not much correlation between years; therefore, water management agencies must always be prepared for a low runoff year. Several proposed CALFED alternative components will boost the available storage or reduce the demands for water supply in dry years. Additional CALFED components will support adjustments in reservoir operations to change the allocation and scheduling of reservoir releases during dry years.



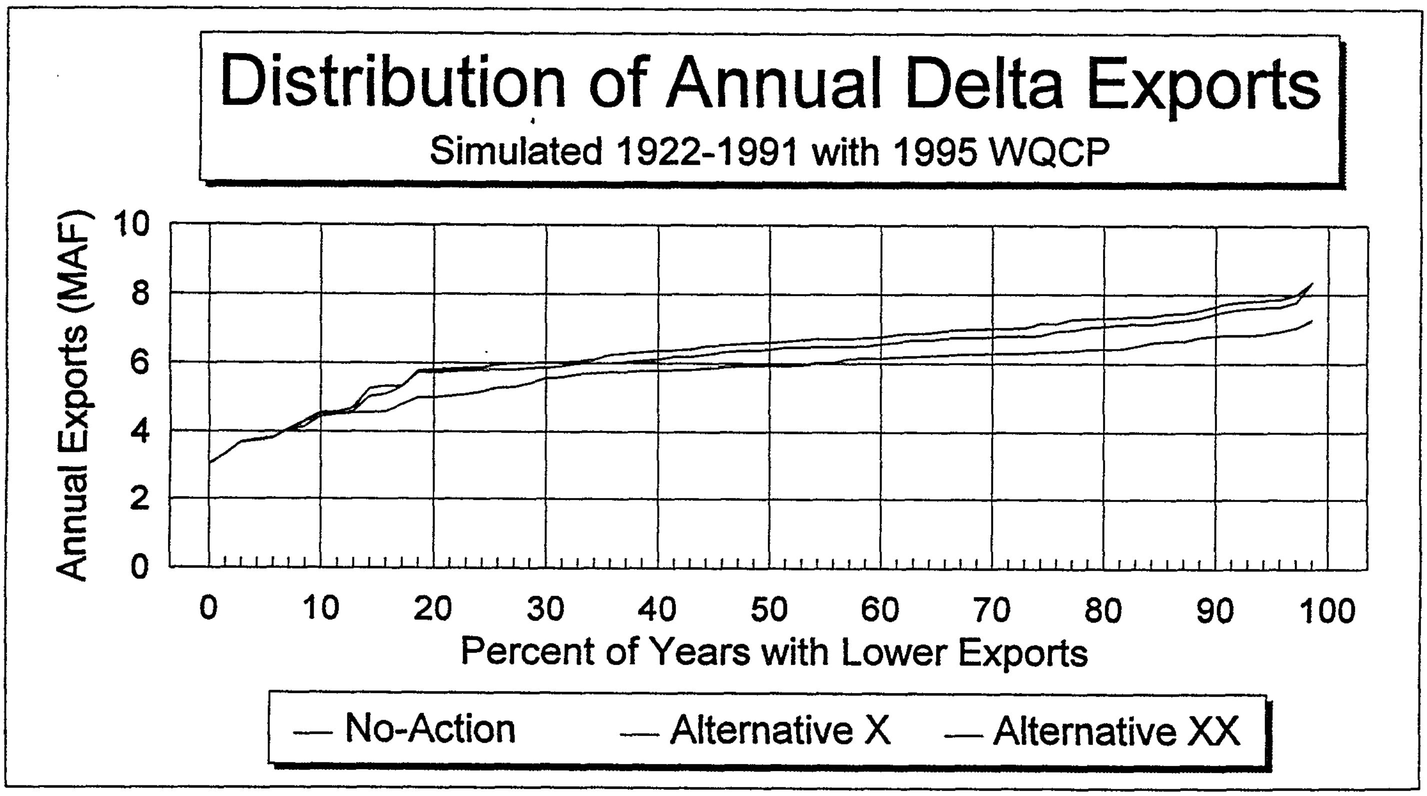
RELATIONSHIP 2

"Monthly Total Delta Inflow" indicates the simulated range of monthly Delta inflow for 1922-1991 needed to satisfy 1995 Water Quality Control Plan objectives and provide Delta exports. The range of Delta inflows is shown with the minimum, 20%, 40%, 60%, 80%, and maximum flow values for each month. The range of annual runoff is sometimes classified with water-year types, although the monthly Delta inflow pattern is only partially determined by the annual runoff or water-year type. The ability to change (increase) the Delta inflow in a particular month is limited by the unimpaired runoff and the upstream storage capacity because some of the available runoff must be stored to provide later releases for demands and instream flow requirements.



RELATIONSHIP 3

"Annual Delta Exports Distribution" indicates that the ability to provide Delta exports while satisfying the 1995 WQCP objectives for Delta outflow and maximum limits on the percent of Delta inflow that can be exported (i.e., export ratio) is often less than the assumed maximum annual demand of 6.7 MAF/year. Available storage, export pumping limits, and other operational constraints included in DWRSIM sometimes reduce the simulated exports. If some of these assumed operational constraints are modified, the simulated monthly export pumping patterns would shift (e.g., reservoir releases might change) and the resulting annual export distribution would change (e.g., increases and decreases are possible). Several CALFED alternative components include potential changes in water management facilities, changes in the monthly allocation of water for instream flows and Delta outflows, as well as changes in habitat features within the Delta and estuary that may require different objectives for protection of multiple beneficial uses within the Delta pool. Changes in the location of the Delta exports and diversions may allow some of the maximum export limits to be modified. Physical pumping and conveyance capacities will continue to constrain the maximum exports during periods of high Delta inflow. Export storage capacity will limit the maximum possible exports in other periods of sustained high inflows.



DeltaSOS Model

Purpose: Evaluate Delta channel flows and operations for alternative Delta water quality and flow objectives, such as D-1485 or 1995 WQCP.

CALFED Potential: Could be used to explore Delta operations of new or modified facilities with alternative water quality objectives. Can provide iterative and interactive evaluation and display of potential Delta operations. Can be used to demonstrate and communicate differences between alternatives.

Approach: Spreadsheet calculations compare initial monthly Delta water budget with specified Delta water quality objectives (flow and export limits) to determine potential effects of objectives on Delta exports.

Inputs: Initial monthly Delta water balance (flows and exports) for 1922-1991; Delta water quality and operations objectives specified as month x year-type values for approximately 25 different operational controls.

Methods: Channel flows estimated with "flow-split" equations based on RMA hydrodynamic model results. Incremental changes in exports are calculated to satisfy specified gate, diversions, outflow, and export objectives.

Results: Monthly Delta channel flows, isolated and direct CVP/SWP exports, outflow, and in-Delta storage operations are calculated as incremental changes from initial values that are required to satisfy specified objectives. Time-series of monthly values with annual summaries; monthly and annual graphics.

Applications: Used to describe in-Delta storage operations for Delta Wetlands EIR/EIS prepared by SWRCB and Corps.

Documentation: Appendix A2 "Delta Standards and Operations Simulation Model" & Appendix A3 "DeltaSOS Simulations of Delta Wetlands Project Alternatives" in Delta Wetlands Project Draft EIR/EIS (September 1995).

Source: Free-access, Lotus 123 Spreadsheet Model, Jones & Stokes Associates, Russ T. Brown (916) 737-3000.

Department of Water Resources Simulation Model (DWRSIM) Version 7.54.

Purpose: DWRSIM was developed by the California Department of Water Resources to simulate the SWP and CVP water systems in the northern central valley and south of the Delta. The model is designed to simulate riverflow and reservoir storage response to reservoir operations, regulatory standards, hydrologic conditions, and water demands. It is an adaptation of an HEC-3 model and has been customized to simulate the SWP system. DWRSIM operates the SWP reservoirs as an integrated unit. The model user can modify input data to assess the effects of such changes on rivers and reservoirs in the model area.

CALFED.Potential: This model is compatible with and can be used in CALFED alternatives analysis

Approach: DWRSIM is an arithmetic accounting of hydrologic conditions within the model boundaries. The model boundaries include the Trinity, Sacramento, Feather, American, and San Joaquin Rivers. These primary rivers are subdivided for model calculations and analyzed in detail. The Yuba, Bear, Mokelumne, Cosumnes, and Calaveras Rivers, and numerous small tributaries, are included in the model at a lesser level of detail. The Stanislaus River is input as a time series developed from STANSIM or a similar model.

Input Data: Input includes data on hydrologic conditions, water demands, regulatory criteria, and operational considerations. Hydrologic data include reservoir inflows, rainfall, evaporation, and river accretions and depletions. Regulatory criteria include instream flow and Delta standards. Operational considerations include reservoir management criteria, flood control requirements, and canal or pump capacity. Data are application-specific and are provided to the model in separate files for each type of input. The user specifies the simulation period; current data sets extend 71 years.

Methods: The model performs mass balance calculations at each model node to estimate several model conditions. The model nodes are approximations for physical conditions and locations. For example, the model starts with the flow into a node, subtracts diversions and losses, and adds water gains to estimate the flow leaving the node.

Results: DWRSIM produces extensive output at each model node in a binary file. Examples of output include data on flow, storage, diversions, deliveries, deficiencies, and regulatory criteria. The output can be accessed directly and presented in tables or graphs.

Applications: DWRSIM is useful in determining the change in a condition that could result from changes in input data. The model is site-specific to the SWP and CVP systems and does not analyze local water projects in detail.

Documentation: There is no official documentation for the current version of DWRSIM.

Source: DWRSIM is available through the California Department of Water Resources, Sacramento, CA.

Project Simulation Model (PROSIM) Version 5.61

Purpose: PROSIM was developed by the U.S. Bureau of Reclamation to simulate the CVP and SWP water systems in the northern central valley and south of the Delta. The model is designed to simulate the riverflow and reservoir storage response to reservoir operations, regulatory standards, hydrologic conditions, and water demands. PROSIM incorporates these criteria and conditions and operates CVP reservoirs as an integrated unit. The model user can modify input to assess the effects of such changes on rivers and reservoirs in the model area.

2

CALFED Potential: This model is compatable with and can be used in CALFED alternatives analysis.

Approach: PROSIM is an arithmetic accounting of specific conditions within the model boundaries. The model boundaries include the Trinity, Sacramento, Feather, American, and San Joaquin Rivers. These primary rivers are subdivided for model calculations and analyzed in detail. The Yuba, Bear, Mokelumne, Cosumnes, and Calaveras Rivers, and numerous small tributaries, are included in the model at a lesser level of detail.

Input Data: Input includes data on hydrologic characteristics, water demands, regulatory criteria, and operational considerations. Hydrologic data include reservoir inflows, rainfall, evaporation, and river accretions and depletions. Regulatory criteria include instream flow and Delta standards. Operational considerations include reservoir management criteria, flood control requirements, and canal or pump capacity.

Methods: The model performs mass balance calculations at each model node to track flow, storage, and other model conditions. The model nodes are approximations for physical conditions and locations. For example, the model starts with the flow into a node, subtracts diversions and losses, and adds water gains to estimate the flow leaving the node.

Results: PROSIM produces extensive output at each model node in a binary file. Examples of output include data on flow, storage, diversions, deliveries, and regulatory criteria. A postprocessor is needed to extract the output from the binary file.

Applications: PROSIM is useful in determining the change in some condition that could result from changes in input data. PROSIM is site-specific to the CVP and SWP systems and does not analyze local water projects in detail. It can also generate data to use in the CVP power model to estimate power generation.

Documentation: Although the model is in wide use with many applications, there is no official documentation for the current version of PROSIM.

Source: PROSIM is available from the U.S. Bureau of Reclamation, Mid-Pacific Regional office in Sacramento, California, or from the Reclamation Home Page on the Internet.

San Joaquin Area Simulation Model (SANJASM)

Purpose: SANJASM was developed to simulate the flow and storage conditions in the San Joaquin River basin by incorporating reservoir operations, flow standards, demands, and hydrology.

CALFEDPotential: SANJASM can be used in CALFED alternatives analysis to evaluate impacts of alternative instream flow criteria, operating procedures, conjunctive-use groundwater schemes, power generation strategies, and new physical facilities between Millerton Lake and the Delta. The output can be flexible to reflect all of the permutations that can be developed among all of the variables available to the summary files.

Approach: SANJASM is an arithmetic accounting of flow and storage within the model boundaries. The model boundaries include the San Joaquin, Merced, Tolumne, Stanislaus, Fresno, Chowchilla, Mokelumne, and Calaveras Rivers. These primary rivers are subdivided for model calculations and analyzed in detail. The Cosumnes River, westside streams, and numerous small tributaries are included in the model at a lesser level of detail. The Friant Unit is included in the model.

Input Data: Input includes data on hydrologic conditions, water demands, regulatory criteria, and operational considerations. Hydrologic data include reservoir inflows, rainfall, evaporation, and river accretions and depletions. Regulatory criteria include instream flow standards and Vernalis water quality standards. Operational considerations include reservoir management criteria, flood control requirements, and canal or pump capacity. Data are application-specific and are provided to the model in separate files for each type. The user specifies the simulation period; current data sets extend 70 years. Groundwater is not simulated in the model.

Methods: SANJASM performs mass balance calculations at each model node to track flow, storage, and other model conditions. The model starts with the flow into a node, subtracts diversions and losses, and adds water gains to estimate the flow leaving the node.

Results: The model can be run two ways: based on historic storages, (resulting in historical releases), or based on inflows and downstream demands limited by flood control rules and minimum conservation pools. Two types of output reports are generated by two postprocessing programs: balance sheets for each of seven model sections, and summaries of a single variable for any consecutive set of years in a simulation.

Applications: SANJASM can be used to describe a multitude of operational and physical changes for the San Joaquin River system between Millerton Lake and the Delta.

Documentation: SANJASM Documentation, Version 2.82, U.S. Bureau of Reclamation, 1993.

Source: Free-access, PC FORTRAN 77 by the Lahey F77L-EM/32 FORTRAN compiler, or UNIX model compiled using Greenhills FORTRAN. Reclamation, (916)979-2276.